

Dec. 13, 1938.

F. E. HARRELL

2,139,748

SQUIRREL CAGE ROTOR AND PROCESS FOR MAKING THE SAME

Filed Nov. 18, 1936

2 Sheets-Sheet 1

Fig-1

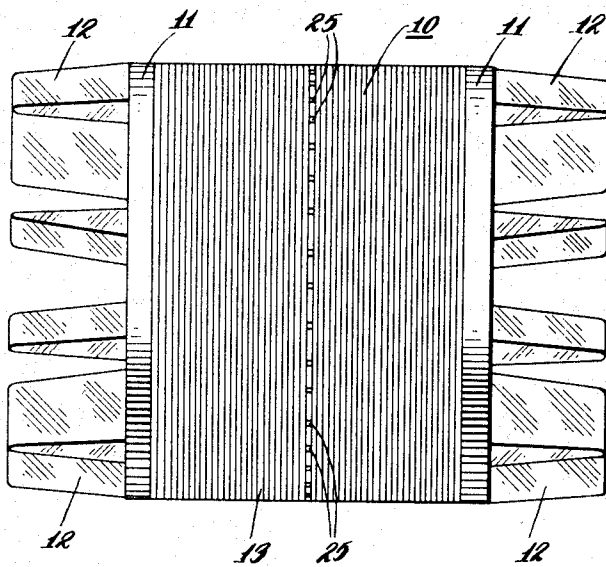


Fig-2

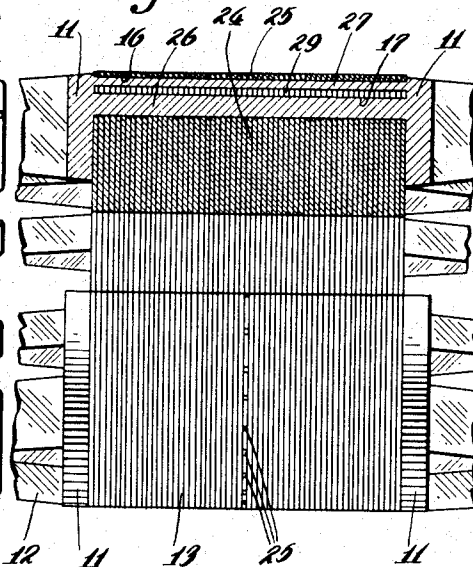


Fig-3

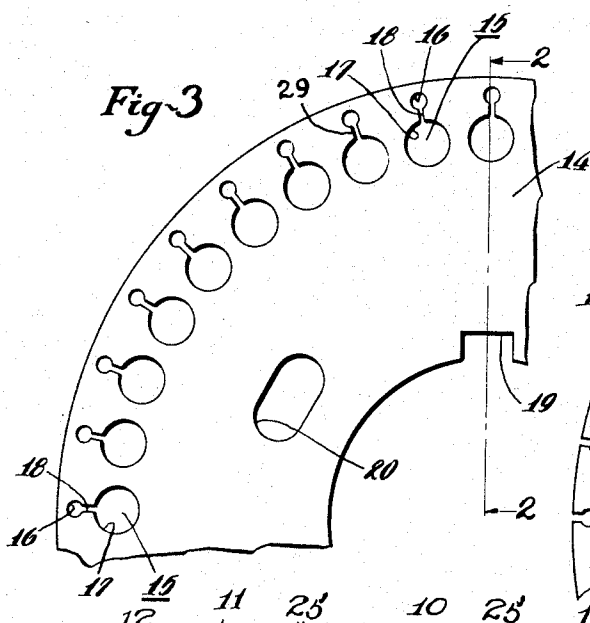


Fig-4

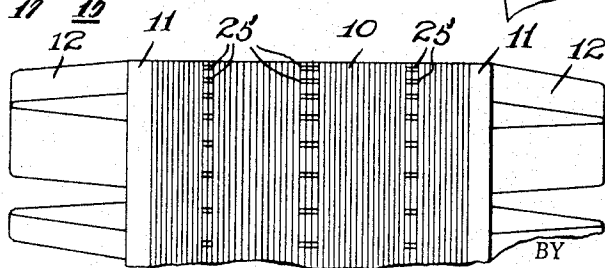
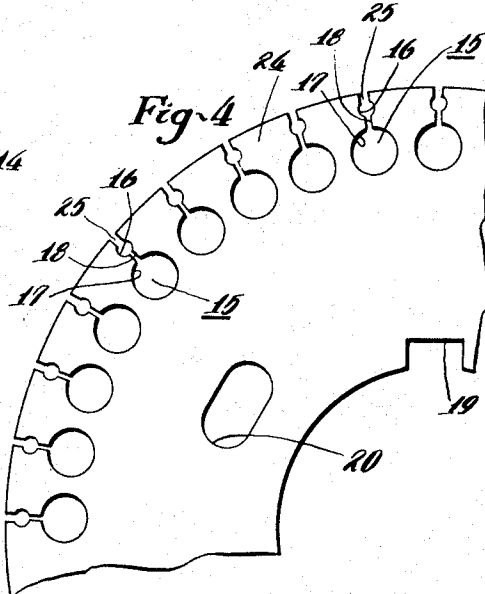


Fig-9

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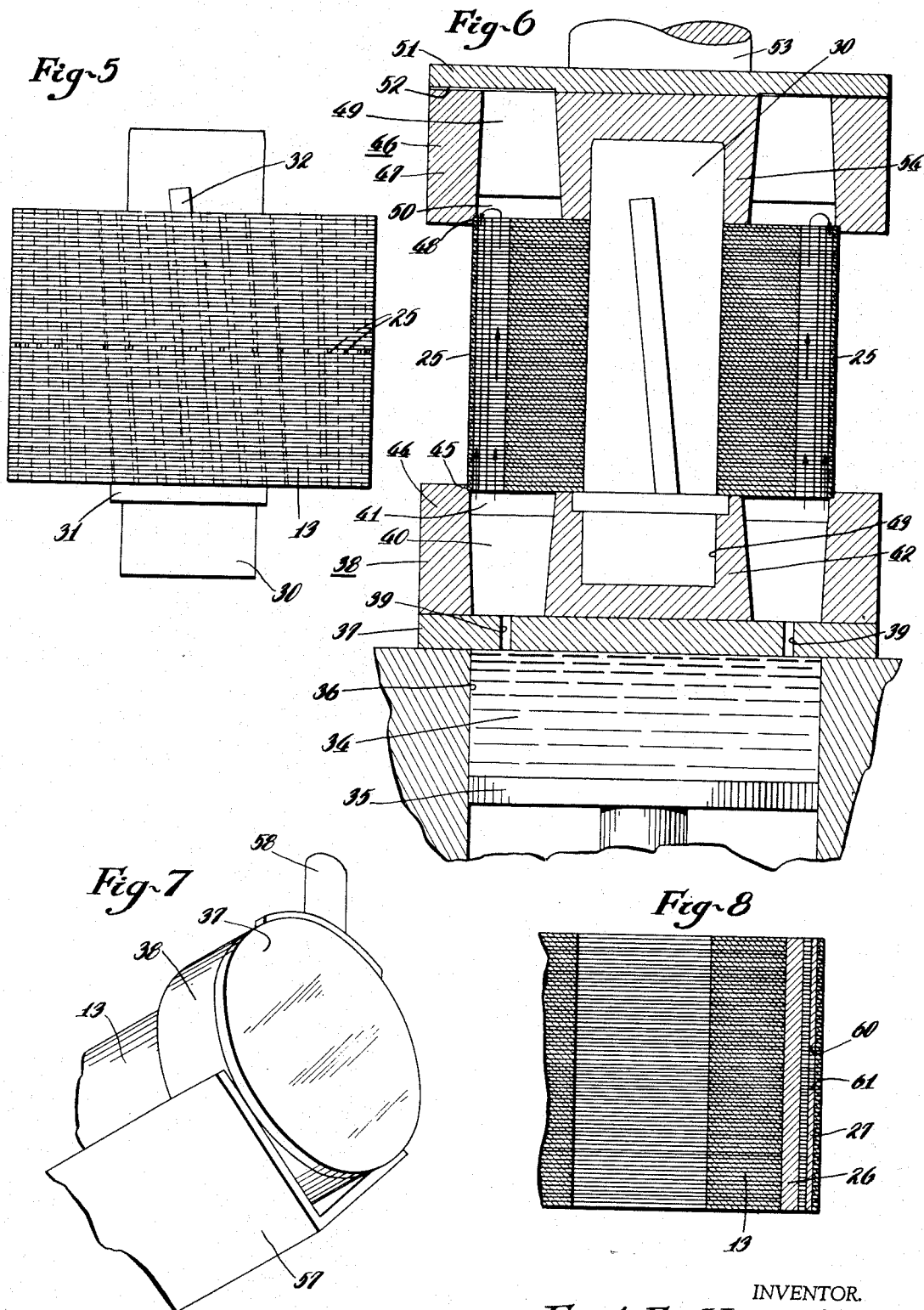
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SQUIRREL CAGE ROTOR AND PROCESS FOR MAKING THE SAME

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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SQUIRREL CAGE ROTOR AND PROCESS FOR
MAKING THE SAME

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2 Claims. (Cl. 172-120)

My invention relates, in general, to squirrel cage rotors and more particularly to cast squirrel cage rotors and the process for making same.

An object of my invention is the provision of a laminated core for squirrel cage rotors having enclosed conductor bar slots arranged below the peripheral surface of the core and extending from one end of the core to the other, each of said enclosed conductor bar slots having a vent intermediate its end.

Another object of my invention is to provide for venting the enclosed conductor bar slots of a squirrel cage rotor intermediate their ends to facilitate the casting of the conductor bars.

Another object of my invention is to insure against casting faulty conductor bars which give poor operating characteristic.

Another object of my invention is the provision of a laminated core for squirrel cage rotors comprising a plurality of assembled laminations, a certain number of said laminations having conductor bar openings disposed inwardly of the peripheral edge thereof and having in addition thereto a vent space for each of said openings to connect the said openings to the said peripheral edge, the remainder of said assembled laminations having only conductor bar openings disposed inwardly of the said peripheral edge.

Another object of my invention is the process of casting enclosed conductor bars of a squirrel cage rotor by venting each of the enclosed conductor bar slots intermediate their ends so that any air which may be entrapped in the said slots may vent to atmosphere as the molten metal enters the said slots.

Another object of my invention is the provision of assembling a core for squirrel cage rotors with two kinds of laminations, one of said kind of laminations comprising conductor bar openings disposed inwardly of the peripheral edge thereof and having in addition thereto a vent space for each of said openings to connect the said openings to the said peripheral edge, and the other said kind of laminations comprising only conductor bar openings disposed inwardly of the said peripheral edge.

Other objects and a fuller understanding of my invention may be had by referring to the following description and claims, taken in combination with the accompanying drawings; in which like parts are designated by like reference characters, and in which:

Figure 1 is a side view of a squirrel cage rotor embodying the features of my invention, showing the vents for the enclosed conductor bar slots;

Figure 2 shows the upper half of the squirrel cage rotor shown in Figure 1 cut in section, the section being taken along the line 2-2 as indicated in Figure 3;

Figure 3 shows a fragmentary view of one kind of lamination used in the assembly of my core for squirrel cage rotors, said lamination having conductor bar openings disposed inwardly of the peripheral edge thereof;

Figure 4 shows a fragmentary view of another kind of lamination used in the assembly of my core for squirrel cage rotors, said lamination having conductor bar openings disposed inwardly of the peripheral edge thereof and having in addition thereto a vent for each of said openings to connect the said openings to the said peripheral edge;

Figure 5 shows the arrangement of the laminations upon a mandrel, preparatory to the process of casting the conductor bars, the short circuiting rings, and the fan blades;

Figure 6 shows a cross sectional view of the assembled laminations, as mounted between a lower and an upper mold for casting the conductor bars, the short-circuiting rings, and the fan blades;

Figure 7 illustrates the method of shearing the gate-plate from the end of the lower mold, preparatory to dismantling the lower and the upper molds from the cast rotor;

Figure 8 shows a fragmentary and cross-sectional view of a laminated core for squirrel cage rotors having no vents, and illustrating the defects which may appear in a conductor bar when cast with no vents, and

Figure 9 is a fragmentary view of a modified form of my squirrel cage rotor.

With reference to Figures 1 and 2 of the drawings, the reference character 10 designates generally a squirrel cage rotor embodying the features of my invention, and comprises a laminated core 13 having the usual short circuiting rings 11 and the fan blades 12 cast integrally with the inner cage conductor bars 26 and the outer cage conductor bars 27.

Heretofore, a great deal of difficulty has been encountered in the casting of the conductor bars, the short circuiting rings, and the fan blades. The main difficulty resided in the fact that there was no sure way of guarding against defects appearing in the casting of the conductor bars within the enclosed conductor bar slots. One of the most common defects arising from these difficulties was the inability to cast the outer cage conductor bars 27 continuously from one end of

the laminated core to the other end. These defects usually took the form of a gap in the intermediate portion of the outer cage conductor bars, as shown between the two ends 60 and 61 of Figure 8. The presence of this gap naturally affected the operating characteristic of the rotor, and particularly during the starting period when substantially all of the current flows through the outer cage conductor bars. Furthermore, there was no way to exercise any design or manufacturing control over the operating characteristics of squirrel cage motors employing these faulty conductor bars since no two rotors would cast alike.

In order to prevent the appearance of the foregoing mentioned defects and particularly the gap in the outer cage conductor bars 27, as indicated between the two ends 60 and 61 of Figure 8, I provide a vent 25 intermediate the ends of each of the conductor bar slots. These vents 25 may be provided in any suitable manner and as preferably carried out in the process of constructing my squirrel cage rotor, I utilize two different kinds of laminations. One kind of lamination is designated by the reference character 14 of Figure 3, and is of the standard closed conductor bar type. As illustrated, it comprises a plurality of peripheral conductor bar openings or slots 15 having relatively large inner cage openings or slots 17 and a plurality of peripheral smaller outer cage openings or slots 16. The inner cage openings or slots 17 and the outer cage openings or slots 16 are interconnected by a gap 18. The arrangement of the size and the shape of the said openings may be varied to accommodate any particular design, and it is understood that the detail of the conductor bar openings need not be restricted to the shape indicated by the reference character 15, but may be any other detail involving the accomplishment of a reduction in area nearer the peripheral edge while maintaining relatively large inner cage openings or slots. When the laminations are assembled and the said openings are registered, the large inner cage openings 17 provide a plurality of inner cage longitudinal slots which extend from one end of the laminated core 13 to the other end, and the small outer cage openings 16 provide a plurality of outer cage longitudinal slots, which also extend from one end of the laminated core 13 to the other end. As is in usual practice, the laminations have ventilating openings 20 and a key way notch 19 for the rotor shaft.

The other kind of lamination is illustrated by the reference character 24 of Figure 4 and comprises substantially the same construction as that shown in Figure 3, except that the small outer cage openings 16 are provided with a vent space 25 to connect the small outer cage openings 16 to the outside of the periphery of the lamination.

In assembling the two kinds of laminations, see Figures 1, 2, 5, 6 and 9, one or more of the laminations 24 shown in Figure 4 may be interposed at various intervals between the laminations 14 shown in Figure 3. In Figures 1, 2, 5 and 6 of the drawings, I have indicated only one such lamination 24 interposed between the laminations 14 to provide the vents 25, but it is to be clearly understood that I do not intend to limit my invention to the use of only one such lamination 24 because one or more may be used, as shown in Figure 9. With only one such lamination 24 employed, as illustrated in Figures 1, 2, 5 and 6 of the drawings, each of the longitudinal enclosed conductor bar slots is vented inter-

mediate its ends, by a single vent 25. As will later appear, this vent 25 facilitates the casting of the conductor bars and particularly prevents the appearance of the gap between the two spaced ends 60 and 61 in the outer cage slots as shown in Figure 8.

In constructing the laminated core 13, the laminations 14 and 24 are arranged as hereinabove described upon a mandrel 30 having shoulder 31, see Figure 5. A key way 32 is provided upon the mandrel 30 in order to align the conductor bar openings to provide the longitudinal and enclosed conductor bar slots. The longitudinal slots may be skewed as indicated by the dotted lines in Figure 5. After the laminations are assembled upon the mandrel 30, the entire assembly is mounted into a lower mold 38, which rests on top of a gate plate 37. The gate plate 37 is arranged to have a series of openings 39, and is adapted to rest upon the upper end of a cylinder 36 containing molten metal 34. In casting the conductor bars, the short circuiting rings and the fan blades, the molten metal is arranged to be urged up through the openings 39 in the gate plate 37 by means of a piston 35. The lower mold 38 has an outer circumferential wall 44 and a central portion 42 having an opening 43 to receive the lower end of the mandrel 30. The lower mold 38 also has a plurality of fan blade cavities 40 arranged substantially radially between the outer circumferential wall 44 and the central portion 42. As illustrated, the fan blade cavities 40 do not extend all the way up to the upper edge of the lower mold. This leaves the concentric space 41 within the lower mold above the fan blade cavities for the molten metal to occupy in casting the short circuiting ring on the lower end of the rotor. As indicated by the reference character 45, the upper inside peripheral edge of the wall 44 of the lower mold 38 is provided with a peripheral notch, into which the lowermost peripheral edge portion of the assembled laminations upon the mandrel 30, closely fit.

An upper mold 46 is somewhat similar to the lower mold 38, and is placed upon the upper end of the assembled laminations. It has a peripheral inner notch 48 which closely engages the uppermost peripheral edge portion of the assembled laminations. As illustrated, the upper mold 46 has an outer circumferential wall 47 and an inner center portion 54 having a central opening to receive the upper end of the mandrel 30. The plurality of fan blade cavities 49 and concentric portion 50 in the upper mold take care of the casting of fan blades and the short circuiting ring upon the upper end of the laminated core. The construction of the fan blade cavities 49 and the concentric short circuiting ring portion 50 of the upper mold is substantially the same as the construction of the fan blade cavities and the short circuiting ring portion in the lower mold 38. A cover 51 is placed on top of the upper mold, and is arranged to have radially extending small groove 52 through which air may escape as the molten metal is forced upwardly into the assembled molds. During the casting operation, a suitable plunger 53 holds the molds tightly upon the assembled laminations.

In casting the conductor bars, the fan blades and the short circuiting rings, the piston 35 is raised to force the molten metal up through the openings 39 in the gate plate, where the molten metal first enters the lower fan blade cavities 40 and then the lower short circuiting ring portion

41. After the fan blade cavities 40 and the short circuiting ring 41 are filled, the molten metal rises up through the conductor bar slots of the laminated core. Because of the relative sizes of the inner cage slots 17 and the outer cage slots 16, the molten metal flows up through the large inner cage slots 17 much faster than it flows through the small outer cage slots 16. This means that the molten metal readily rises through the large inner cage slots as indicated by the arrows in Figure 6, and then overflows and falls down into the small outer cage slots 16, as further indicated by the arrows. By reason of this condition, air is entrapped between the two approaching columns of metal, and if the air were not allowed to escape through the vents 25, it would prevent the two approaching ends of the molten metal from coming together and from producing a continuous conductor bar. Therefore the function of the vents 25, is to allow the entrapped air to escape, with the result that the two approaching columns of molten metal may come together and make a solid and continuous outer cage conductor bar in the small outer cage slots. The solid and continuous conductor bars, as made in accordance with my invention, are illustrated by the sectional view in Figure 2, where the reference character 26 indicates the large inner cage conductor bar as cast in the large inner cage slot 17, and where the reference character 27 indicates the small outer cage conductor bar as cast in the small outer cage slot 16. The reference character 29 represents the side of the gap 18, when the section is taken along the line 2—2 of Figure 3.

After the conductor bar slots are filled, the molten metal continues to rise and fill first the upper short circuiting ring portion 50 and then finally the upper fan blade cavities 49. The air which may be trapped in the upper mold escapes through the small radial groove 52. The radial grooves 52 are not very big so that very little, if any, of the molten metal can escape there-through.

After the molten metal has chilled and solidified, the next process is to remove the molds. The upper mold 46 may be readily removed by elevating it from the upper end of the assembled rotor. However, before the lower mold can be removed, it is necessary to shear the gate plate 37 from the lower end of the mold. This may be done by placing the assembly including the lower mold within a V-shaped support 57 as illustrated in Figure 7, and then by using a power actuated plunger 58 to shear the gate plate 37 from the end of the mold 38. When the plunger 58 is moved downwardly, the chilled metal in the gate plate openings 39 is sheared from the end of the lower fan blades in the fan blade cavities 40. After the gate plate 37 is moved, the lower mold 38 may be readily removed. When this is done, the rotor is finished, so far as the casting is concerned.

The size of the vents 25 are not very large and thus only a very small amount of the molten metal tends to escape therethrough, and this small amount serves as an indication that the conductor bars are cast solid.

Although I have described my invention with a

certain degree of particularity, it is understood that the present disclosure has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention as hereinafter claimed.

I claim as my invention:

1. In an induction motor, a squirrel cage rotor having inner and outer concentric rows of enclosed conductor bar receiving openings connected together by narrow slit portions, said conductor bar receiving openings arranged below the peripheral surface of the rotor and extending from one end of the rotor to the other, each of said outer enclosed conductor bar receiving openings having intermediate its ends a transverse opening extending to the peripheral surface of the rotor, conductor bars molded in the outer and inner conductor bar receiving openings and the narrow slit portions, end rings molded integrally to the ends of the conductor bars, the inner row of conductor bars comprising a solid molded mass of metal and being large in cross-sectional area to give a low resistance and a high reactance, the outer row of conductor bars comprising a solid molded mass of metal and being small in cross-sectional area to give a high resistance and a low reactance, each of said outer row of conductor bars comprising two end portions and an intermediate portion, said intermediate portion electrically connecting the two end portions together as a solid mass and projecting outwardly through the transverse openings toward the peripheral surface of the rotor to indicate the establishment of the electrical connection between the two end portions.

2. In an induction motor, a squirrel cage rotor having inner and outer concentric rows of enclosed conductor bar receiving openings connected together by narrow slit portions, said conductor bar receiving openings arranged below the peripheral surface of the rotor and extending from one end of the rotor to the other, each of said outer enclosed conductor bar receiving openings having intermediate its ends, a plurality of transverse openings extending to the peripheral surface of the rotor, conductor bars molded in the outer and inner conductor bar receiving openings and the narrow slit portions, end rings molded integrally to the ends of the conductor bars, the inner row of conductor bars comprising a solid molded mass of metal and being large in cross-sectional area to give a low resistance and a high reactance, the outer row of conductor bars comprising a solid molded mass of metal and being small in cross-sectional area to give a high resistance and a low reactance, each of said outer row of conductor bars comprising two end portions and an intermediate portion, said intermediate portion electrically connecting the two end portions together as a solid mass and projecting outwardly through the transverse openings toward the peripheral surface of the rotor to indicate the establishment of the electrical connection between the two end portions.

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